TECHNO ECONOMY DESIGN AND ANALYSIS of OPTICAL MULTI RATIO SPLITTER GPON FTTB for TRIPLE PLAY SERVICES

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Abstract

The ability of the optical fiber to transmit three different wavelengths designed to produce output 32 customers (home pass) with an optical splitter ratio of 1: 4 and 1: 8 .This would be problematic when the number of requests in an area with a demand that vertical building in an area .There some way to meet the demand that vertical building request by way of re-engineering of optical networks to meet the demand and meet triple play services at the speed of 10 Mbps up to 100 Mbps . It is also necessary to optimize cost when deploying optical network infrastructure.

In this study, we present a modified optical splitter ratio of 1: 4 and 1: 8 into the optical splitter ratio of 1: 8 and 1:16 and conduct comparative analysis with a splitter ratio of 1: 4 and 1:32 and analyze shifting distance from the feeder cable Optical Line Termination up to Optical Distribution Cabinet .The traffic analysis and techno economic analysis to determine the feasibility of deploying the infrastructure.

Based on the research we Investigate feasibility analysis of network and Comparison for Optical Splitter 1:32 and two Stage 1: 8 and 1:16, 1: 4 and 1:32 and Evaluate the actual cost of benefits, we performed a detailed techno economic analysis. For the estimation of the OSP CAPEX per user. In this study, it can be proven that a decline in investment costs by 32%, Cost per user before the design is at 15 US $ per user, while after design changes to 13 US $ per user. The design of the use of the Multi Ratio Splitter 1: 8 and 1:16 still meet the criteria for Link Power Budget <28 dB so that proper for deployments. More flexible deployments (in terms of trenches 'and ducts' sizes) are expected to further improve the cost savings and increase of the estimation for 32% cost reduction

Keywords: Multi optical splitter, investment Feasibility Analysis, GPON, FTTx

1. INTRODUCTION

The growing popularity of the Internet, IPTV, Video On Demand, Video Conferencing, Gaming are the key factors behind the development of new access method which would meet the bandwidth requirement[1] . Access network based on copper has distance and bandwidth limitation and will start running out of capacity in near future. The access methods based on the optical fiber are getting more and more attention as they offer the ultimate solution in delivering different services to the customer premises .

1.1 Latar Belakang

The PON is an access network based on Optical Fiber A passive Optical network is a single, shared optical fiber that uses a passive optical splitter to divide the signal towards individual subscribers. PON is called passive because other than at the central office there are no active elements within the access network.

In designing the FTTH network is very important to know about the active device technology, as something to do with the use of the optical core. In this design configuration FTTH passive splitter that there could be promulgated in ODF, ODC and in ODP depending on demand conditions . Because FTTH should be able to serve up to 100 Mbps bandwidth optical splitter output is the maximum allowable total of 32, so the combination splitter installation is single stage using Splitter n: 32 and Splitter Two Stage using a combination of n:4 and n : 8, or n : 2 and n: 16**.**

With the increasing demand for bandwidth and the number of very high service such as high definition IP Television (IPTV), Service Providers and demand in an area and building on the existing optical networks that use Passive Optical Networks by combining optical splitter 1: 8 and 1:16 to meet the needs and increase the bandwidth capacity of current and future. Progress towards the growth of a very high market share in the broadband needs accompanied by income growth. This requires the operator to perform a search technology with capital expenditure (CAPEX) and operational expenditure (OPEX) low capacit y to meet traffic growth with infrastructure solutions more effective and cheaper. One step cost optimization is done by optimization of the optical splitter ratio of 1: 4 and 1: 8 to 1: 8 and 1:16.

1.2 Batasan Masalah

To achieve the objective of this study, some problems need to be studied, which are listed below

1 Problem is limited in the installation passive Splitter mounted on two points, mounted in ODC capacit y1: 8 and 1:16 in ODP capacity. Calculation of the received signal power at the receiver

2 This study focus on Calculation Calculating maximum cable distance and the cash flow analysis it can be seen a decent investment or not.

1.3 Masalah

To achieve the objective of this study, some problems need to be studied, which are listed below:

- Anticipate the need for capacity home pass and meet Quality of Service and cost effective
- Shorten the distance to the OLT optical splitter without reducing the quality of triple play services

2. PASSIVE OPTICAL NETWORK REVIEW

2.1 Jaringan Optik Pasif

A PON is a fiber network that only uses fiber and passive components like splitters and combiners rather than active components like amplifiers, repeaters, or shaping circuits. Such networks cost significantly less than those using active components. The main disadvantage is a shorter range of coverage limited by signal strength. While an active optical network (AON) can cover a range to about 100 km (62 miles), a PON is typically limited to fiber cable runs of up to 20 km (12 miles). PONs also are called fiber to the home (FTTH) networks.

The term FTTx is used to state how far a fiber run is. In FTTH, x is for home. You may also see it called FTTP or fiber to the premises. Another variation is FTTB for fiber to the building. These three versions define systems where the fiber runs all the way from the service provider to the customer. In other forms, the fiber is not run all the way to the customer. Instead, it is run to an interim node in the neighborhood. This is called FTTN for fiber to the node. Another variation is FTTC, or fiber to the curb. Here too the fiber does not run all the way to the home. FTTC and FTTN networks may use a customer’s unshielded twisted-pair (UTP) copper telephone line to extend the services at lower cost. For example, a fast ADSL line carries the fiber data to the customer’s devices.

The typical PON arrangement is a point to multi-point (P2MP) network where a central optical line terminal (OLT) at the service provider’s facility distributes TV or Internet service to as many as 16 to 128 customers per fiber line *(see the figure)*. Optical splitters, passive optical devices that divide a single optical signal into multiple equal but lower-power signals, distribute the signals to users. An optical network unit (ONU) terminates the PON at the customer’s home. The ONU usually communicates with an optical network terminal (ONT), which may be a separate box that connects the PON to TV sets, telephones, computers, or a wireless router. The ONU/ONT may be one device. In the basic method of operation for downstream distribution on one wavelength of light from OLT to ONU/ONT, all customers receive the same data. The ONU recognizes data targeted at each user.

For the upstream from ONU to OLT, a time division multiplexer (TDM) technique is used where each user is assigned a timeslot on a different wavelength of light. With this arrangement, the splitters act as power combiners. The upstream transmissions, called burst-mode operations, occur at random as a user needs to send data. The system assigns a slot as needed. Because the TDM method involves multiple users on a single transmission, the upstream data rate is always slower than the downstream rate.

2.2 GPON (**Gigabit Passive Optical Network)**

Over the years, various PON standards have been developed. In the late 1990s, the International Telecommunications Union (ITU) created the APON standard, which used the Asynchronous Transfer Mode (ATM) for long-haul packet transmission. Since ATM is no longer used, a newer version was created called the broadband PON, or BPON. Designated as ITU-T G.983, this standard provided for 622 Mbits/s downstream and 155 Mbits/s upstream.

While BPON may still be used in some systems, most current networks use GPON, or Gigabit PON. The ITU-T standard is G.984. It delivers 2.488 Gbits/s downstream and 1.244 Gbits/s upstream. GPON uses optical wavelength division multiplexing (WDM) so a single fiber can be used for both downstream and upstream data. A laser on a wavelength (λ) of 1490 nm transmits downstream data. Upstream data transmits on a wavelength of 1310 nm. If TV is being distributed, a wavelength of 1550 nm is used.

While each ONU gets the full downstream rate of 2.488 Gbits/s, GPON uses a time division multiple access (TDMA) format to allocate a specific timeslot to each user. This divides the bandwidth so each user gets a fraction such as 100 Mbits/s depending upon how the service provider allocates it. The upstream rate is less than the maximum because it is shared with other ONUs in a TDMA scheme. The OLT determines the distance and time delay of each subscriber. Then software provides a way to allot timeslots to upstream data for each user.The typical split of a single fiber is 1:32 or 1:64. That means each fiber can serve up to 32 or 64 subscribers. Split ratios up to 1:128 are possible in some systems. As for data format, the GPON packets can handle ATM packets directly. Recall that ATM packages everything in 53-byte packets with 48 for data and 5 for overhead.

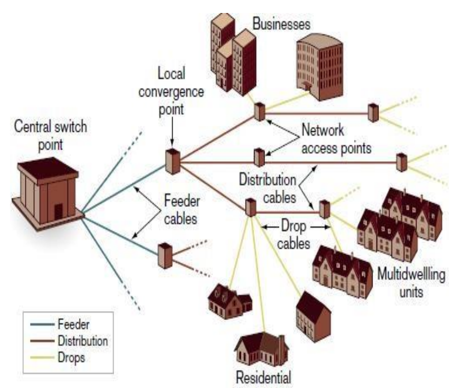

Fig 1. Most PONs comprise a central switch point [2]

3. SYSTEM DESIGN

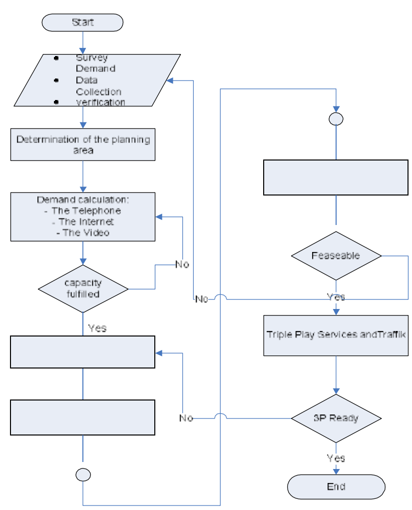

Fig 2. Flowchart planning

In conducting the necessary planning stages to support network planning. In this

In planning, to be determined location of the target planning. In this thesis, the area chosen for further network planning based Fiber to the building (FTTB) by using GPON is the small write Appartement Building because:

- Growth in demand for Triple play services is quite high.
- Included in the category with the contribution of a high enough income each month.

3.1 **Pendekatan Permintaan Makro**

Calculations on demand forecasting in this thesis using only linear trend method approach. From calculations using linear trend can be expected number of customers next few years, and the final project will be forecasting for 5 (five) years. The calculation is done using the method of linear trend using the

equation $Y = a + bX$ [16] (1)
where:

Y = the dependent variable multiplication results

X = independent variable in the form of a period of time

a & b = constants (calculated from sample data) [5]

$$b = n\sum(X_iY_i) - \sum X_i \frac{\sum Y_i}{n\sum(X_i^2)} \qquad (2)$$

$$a = \sum Y_i - \frac{b\sum X_i}{n} \quad [16] \qquad (3)$$

As mentioned earlier, the number of customers who are on the small write current FTTH total of 237 customers. In forecasting demand, taken estimated total monthly subscriber growth as much as 20% per month

Table 1. Linear Methods trend

Month	Months - (Xi)	Total (Yi)	Xi²	Xi.Yi
April '15	1	237	1	237
May '15	2	284	4	569
Juni'15	3	341	9	1.024
July'15	4	410	16	1.638
August'15	5	491	25	2.457
September'15	6	590	36	3.538
October'15	7	708	49	4.954
November'15	8	849	64	6.794
December'15	9	1.019	81	9.172
January'16	10	1.223	100	12.229
February'16	11	1.467	121	16.142
Mart'16	12	1.761	144	21.131
April '16	13	2.113	169	27.471
Total	91	11.494	819	107.335

paper ,network planning stages as follows

Linear trend equation method Y = a + bX
Where: Y = the dependent variable estimates are

X = the independent variable in the form of a period of time

a & b = constants (calculated from sample data)

then obtained by the equation Y = -150.4348139 + 147,7950266X

3.2 **Pemodelan Multi Ratio Optical Splitter**

In designing the FTTB network is very important to know about the active device technology, was connected with the use of optical core, On guide or manual technology used here is GPON.In this configuration there FTTB design the placement of passive splitter can be in ODF, ODC and in ODP depending on the condition of his demand. Because FTTB should be able to serve the

bandwidth Up to 100 Mbps , the maximum allowable spliting is as much as 32, so that the combination of a splitter in the installation into the following :

•Single Stage using Spliter n: 32

• Two Stage using a combination Spliter

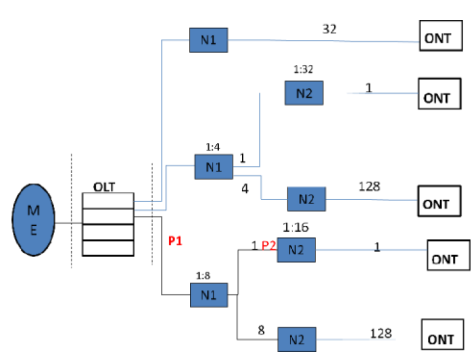

Fig 3. Design Multi Ratio Optical Splitter 1:32,1:4 and 1:32 , 1:8 and 1:16

3.2.1 Link Power Budget

Power link budget calculations carried out in order to determine the total attenuation

limits are allowed between the transmitter output power and receiver sensitivity. Reference on which to base the calculation of link power budget is the ITU-T standard G-

984.3, total attenuation network is not more than 28 dB. Link power budget can be calculated:[5] :

$$\alpha_{total} = L\alpha_{fiber} + N_c\alpha_c + N_s\alpha_s + S_p \quad (4)$$

form equation to determine the power margin is[5]

$$M = (P_t - P_r) - \alpha_{total} - S_M \quad (5)$$

where,

Pt = Power output optical source (dBm),Pr = maximum power detector sensitivity

(dBm),SM = Safety Margin, the range of 6-8 dB ,αtotal = total damping system (dB) ,L = length of optical fiber (Km) ,αc = damping connector (dB / connector, αs = Damping Connection (dB / connection) αfiber = attenuation of optical fiber (dB / Km) ,Ns = Number of connections ,Nc = Number of connectors ,Sp = Splitter Attenuation (dB) .Power margin is the result of power calculation contained in the transmit power is then reduced sensitivity receiver, then subtracted from the loss during transmission, and a reduction in the value of safety margin. This calculation results should be above 0 (zero) dB designed so that network still has enough power to transmit information from the sender to the recipient.

3.2.2 Rise Time Budget

Rise time budget is the calculation of the optical link based on the dispersion that occurs on the link. Rise time occurs due to the limitations of optical sources that can not be activated immediately when the signal to fire. There are four basic elements that limit the speed of the system, namely, rise time transmitter t_{Tx}, rise time dispersion material (material) optical fiber t_{mat} , t_{mod} intermodal dispersion rise time, and rise time receiver t_{Rx}. In general, the degradation of the total transition time a digital link does not exceed

70% of a bit period NRZ (non-return to zero)

or 35% of a bit period RZ (return to zero). To calculate the rise time budget can be done with the equation [5]

$$t_{total} = (t_{tx}^2 + t_{mat}^2 + t_{mod}^2 + t_{rx}^2)^{\frac{1}{2}} \quad (6)$$

t_{Tx}= rise time transmitter t_{Rx}= rise time receiver the response generated by the photodetector and 3 dB bandwidth of the receiver. t_{mat} = material dispersion

$$t_{mat} = D_{mat} x \tau_{\lambda} x L \quad (7)$$

Where : D_{mat} = fiber material dispersion factor ,σ_{λ} = The spectral width of the optical source ,L = fiber length (Km)

t_{mod} = rise time dispersion moda

$$t_{mod} = \frac{440L^q}{B_0} \quad (8)$$

Bo = bandwidth at 1 Km long optical cable
q = parameters fiber length, worth 0.5 ,t_{mod} is 0 (zero) on a single fiber mod**.**

3.2.3 Bandwidth per pengguna dan segmentasi kebutuhan

The cost of the access network has a significant contribution to the overall cost of a telecommunications network and thus it is justifiable to compare the access network cost of the various optical access techniques. The total cost is access technology dependent, but common to all techniques is that the cost depends strongl y on the number of connected customers and on the offered bandwidth per customer. These two together contribute to the number of required network segments.[17]

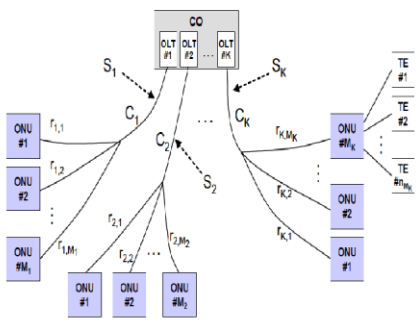

Fig 4 . PON Network Lay Out

Assume that the total transport capacity of segment *Sk* is *Ck* and utilization of the transport channel is ρ, then the total bit rate *Rk* available for user data (excluding line coding) in segmen t *Sk* is [17]

$$R_k = \rho C_k \qquad (9)$$

where : R_k = Total bit rate available for user data, ρ= transport channel, C_k =Total Transport capacity of segment The total bit rate of each segment is the sum of the traffic from all ONUs, connected to segment *Sk* [17]

3.3 TECHNO ECONOMIC ANALYSIS

For Fig.5 to plan the implementation of a technology requires a consideration of the technological aspect also in the economic aspect. One way to consider the implementation of the technology is to follow the terms of reference of techno economic analysis that includes economic and technological considerations. In techno economy will also be an analysis of the technological and economic design

In this thesis used methods of capacity and coverage estimation to determine the design of the technology and methods MROs DCF (Discounted Cash Flow) to measure the feasibility of the costs incurred for the implementation of the Multi Ratio Optical Splitter.

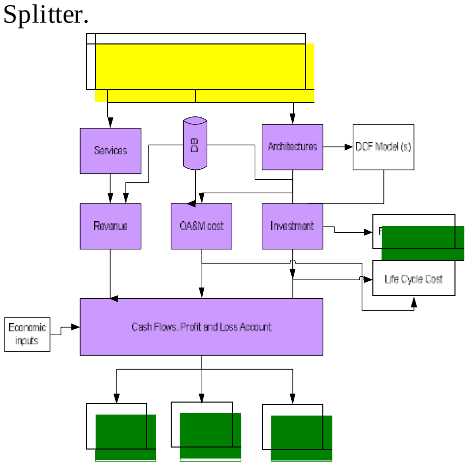

Fig 5. Flowchart of Cash Flow Calculation

4.SIMULATION AND ANALYSIS

4.1 Kelayakan Analisa Jaringan

After designing a network of Optical Distribution Cabinet (ODC) to Optical Distribution Point (ODP) in the High Rise Building GPON technology, the next step is to analyze the feasibility of such a network has been designed. This feasibility analysis using parameters link power budget and rise time budget

Power link budget calculations carried out in order to determine the total attenuation limits are allowed between the transmitter output power and receiver sensitivity.

Reference on which to base the calculation of link power budget is the ITU-T standard G-984.3, total attenuation network is not more than 28 dB. Link power budget can be calculated by the equation[5]

Power link budget calculations will be two parts and will calculate the farthest distance from ODC (Optical Distribution Cabinet) to the ODP (Optical Distribution Point). Determination use farthest distance is because when reckoning the farthest distance has been qualified or meet the eligibility network, the more distance will be eligible eligibility closest of the network as well. In addition GPON wavelength is asymmetric, ie 1310 nm to 1490 nm for the uplink and downlink. Therefore the calculation of the feasibility of the network will be divided into two, the first calculation on the side of the second uplink and downlink sides calculation

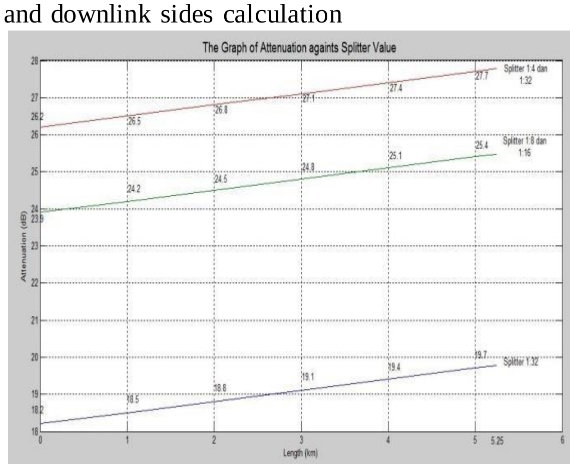

Fig 6. The Graph of Link budget power for optical splitter

For this example, t_{MD}=0, t_{TR}=100 ps, t_{RC}=0.5 ns, and t_{GVD}= 21.8 ps as before. t_r is therefore

510 ps, and the rise time budget does not meet the limit.

• Can use NRZ format,Use faster detector or transmitter,Use graded-index fiber for less dispersion

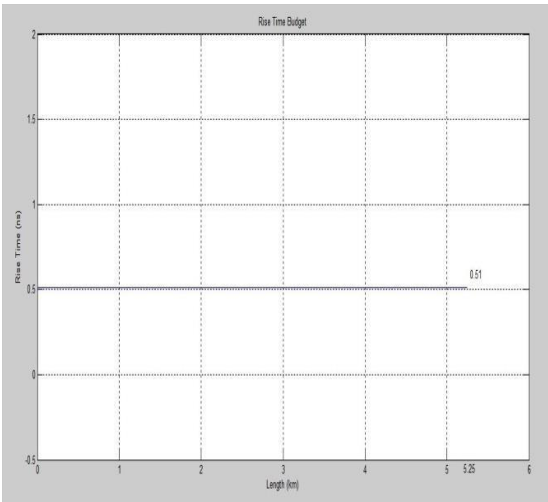

Fig 7. The Graph of Rise time budget for optical splitter

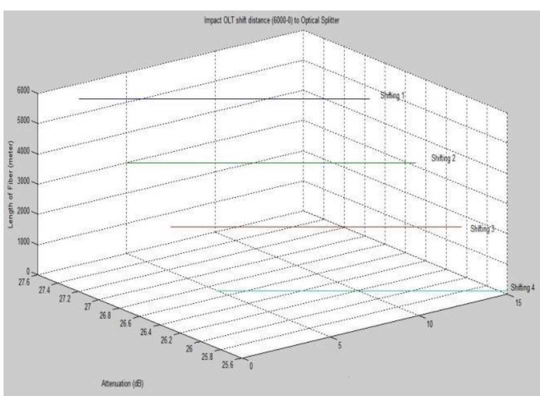

Fig 8. The Graph of Impact OLT shift distance to an Optical splitter 1:8 and 1:16

Analysis of User Needs

From equation (9) Assume that the total transport capacity of segment *Sk* is *Ck* and utilization of the transport channel is ρ, then the total bit rate *Rk* available for user data

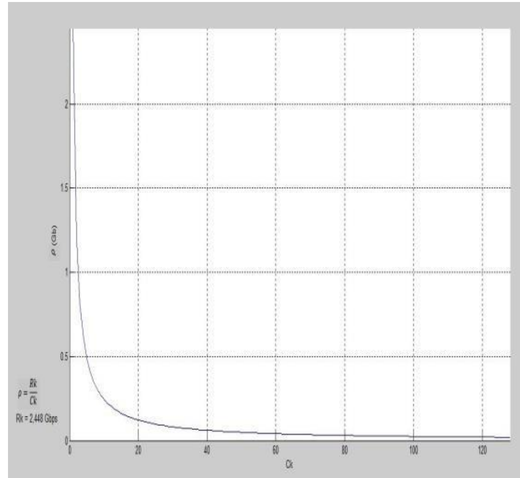

Fig 9. The Graph of Performance Metrics (bitrate available 128 Home Connected)

4.2 FEASIBILITY ANALYSIS TECHNOLOGY IMPLEMENTATION FTTx ACCESS NETWORK

By using the assumptions as mentioned above, it can be calculated the amount of the required OLT in the EPON-based FTTx implementations and GPON for building vertical area with customers triple play .

From the analysis carried out on the economic value will be the scenario so as to obtain the right strategy for telecommunications operators to implement a two-stage MROs 1: 8 and 1:16 on the FTTH network. Implementation MROs conducted cascading network with FTTH network. This is done as a strategy to lower the cost of CAPEX / OPEX issued the operator. In this thesis used optical splitter deployment scheme with two level shifting distance feeder OLT to ONT position

Economic analysis using the DCF method is the observation parameters NPV, IRR and PBP. So that the value of the feasibility of implementation MROs 1: 8 and 1:16. From the results obtained sensitivity and risk analysis of various parameters to obtain some conditions in order to know the value of the upper limit and lower limit eligibility

Table2. Analysis Investment and Depreciation before design

Valuation (Million IDR)

Year to	0	1	2	3	4	5	6	7	8
Revenue	-	27.122	32.501	32.826	33.154	33.486	33.821	34.159	34.500
Expenses	9.149	11.861	12.399	12.432	12.464	12.498	12.531	12.565	12.599
EBITDA	(9.149)	15.261	20.102	20.394	20.690	20.988	21.290	21.594	21.901
EBITDA Margin	#DIV/0!	56%	62%	62%	62%	63%	63%	63%	63%
Depreciation	221	441	441	441	441	441	441	441	221
EBIT	(9.370)	14.820	19.661	19.953	20.249	20.547	20.848	21.153	21.681
Taxes (30%)	(2.811)	4.446	5.898	5.986	6.075	6.164	6.255	6.346	6.504
(+) NOPAT (EBIT - Tax)	(6.559)	10.374	13.762	13.967	14.174	14.383	14.594	14.807	15.177
(+) Depreciation	221	441	441	441	441	441	441	441	221
(-) CAPEX	2.206	-	-	-	-	-	-	-	-
Net Cash flow	(8.544)	10.815	14.204	14.408	14.615	14.824	15.035	15.248	15.397
Discounted Net Cash flow	(8.544)	9.244	10.376	8.996	7.799	6.761	5.861	5.081	4.385
Cumulative Net Cash flow	(8.544)	700	11.076	20.072	27.871	34.633	40.494	45.574	49.959
WACC + Premium	17,00%								
NPV	49.959								
IRR	143%	1	0	0	0	0	0	0	0
Payback Period	1 Year								
	- Month								

Table3. Analysis Investment and Depreciation after design

Valuation (Million IDR)

Year to	0	1	2	3	4	5	6	7	
Revenue	-	27.122	32.501	32.826	33.154	33.486	33.821	34.159	34.500
Expenses	9.149	11.861	12.399	12.432	12.464	12.498	12.531	12.565	12.
EBITDA	(9.149)	15.261	20.102	20.394	20.690	20.988	21.290	21.594	21.901
EBITDA Margin	#DIV/0!	56%	62%	62%	62%	63%	63%	63%	
Depreciation	197	394	394	394	394	394	394	394	197
EBIT	(9.346)	14.868	19.708	20.001	20.296	20.595	20.896	21.200	21.
Taxes (30%)	(2.804)	4.460	5.912	6.000	6.089	6.178	6.269	6.360	6. 511
(+) NOPAT (EBIT - Tax)	(6.542)	10.407	13.796	14.001	14.207	14.416	14.627	14.840	15.
(+) Depreciation	197	394	394	394	394	394	394	394	197
(-) CAPEX	1.968	-	-	-	-	-	-	-	
Net Cash flow	(8.313)	10.801	14.189	14.394	14.601	14.810	15.021	15.234	15.
Discounted Net Cash flow	(8.313)	9.232	10.366	8.987	7.792	6.755	5.856	5.076	4. 383
Cumulative Net Cash flow	(8.313)	918	11.284	20.271	28.063	34.818	40.673	45.749	50.
WACC + Premium	17,00%								
NPV	50.132								
IRR	147%								
Payback Period	1 Year								
	- Month								

From Table 2 and Table 3 , it can be proven that a decline in investment costs by 32% Cost per user before the design is at 15 US$ per user, while after design changes to 13 US$ per user

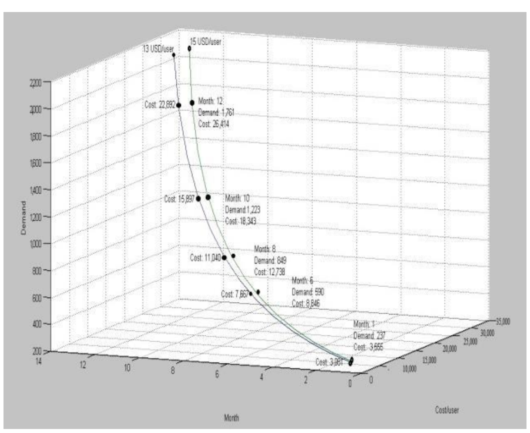

Fig 13. Comparison between the growth of demand and the cost per customer

5. CONCLUSIONS

In this study, we investigate feasibility analysis network and Comparison for Optical Splitter 1:32 and two Stage 1:8 and 1:16 ,1:4 and 1:32 and The design of the use of the Multi Ratio Splitter 1: 8 and 1:16 still meet the criteria Link Power Budget < 28 dB so that proper for deployments .The shifting to the OLT placement Optical Splitter placed in high rise buildings can reduce operational costs , it can be proven that a decline in investment costs by 32% and Cost per user before the design is at 15 US$ per user, while after design changes to 13 US$ per user . We presented a techno-economic study on the OSP costs before design NPV is 49,959 , IRR is 143% and PBP 1 year ,but after design the NPV is 50,132 , IRR is 147% and PBP 1 year . The shifting distance Optical Splitter OLT to a maximum of 5,25 Km in the calculation of maximum attenuation of 27.37 dB

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